Inelastic Cold Neutron Spectroscopy (IN500)

Neutron scattering is used by a worldwide community of about 7000 physicists, chemists, engineers, life scientists, and geologists, as an important tool in condensed-matter research. As of today, the large majority of this work is performed on research reactors as neutron sources. Spallation sources play a complementary role, with reactors offering superior neutron beam performance in 70% of the experiments. Further progress in neutron-scattering research depends on our capability of making spallation sources first competitive, and ultimately superior to reactors in core applications in which reactors provide much superior performance than spallation sources. This revolution in neutron-scattering science is the challenge of the next decade.

LANSCE made the first major step in realizing this revolution by installing at the Lujan Center the first coupled moderators, which can produce up to 6 to 8 times more useful neutrons for the same driving proton beam power than those used at other leading spallation sources. This high neutron intensity comes in long pulses with significant intensities up to 3 to 4 ms from the beginning of the pulse. All future spallation source projects coming on line in 7 to 10 years plan to use these moderators, but as of today, there is no experience available with their use. The IN500 Laboratory Directed Research and Development project at LANSCE is developing a series of novel approaches specifically conceived to establish the use of these long pulses (mechanical pulse shaping, repetition rate multiplication, and enhanced neutron optical beam extraction and delivery system). Implemented on the novel coupled H_2 moderator at the Lujan Center, these techniques will for the first time open up the way for spallation sources to surpass the capabilities of the most advanced reactor facilities in one of their core competencies, cold neutron spectroscopy. This is a crucial research tool for the study of soft and complex matter, including collective phenomena in polymers, biological matter, soft metals such as plutonium, liquids, and nanostructured matter, etc.

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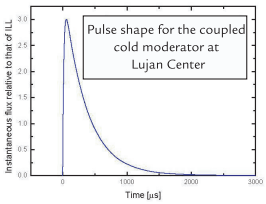
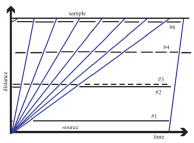
Margarita Russina and Ferenc Mezei review blueprints for the new IN500 instrument.

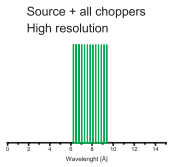
- Coupled moderators
  - offer 5-7 times higher time average flux than the currently used decoupled moderators



- Repetition Rate Multiplication Principle
  - use of a set of monochromatic pulses from each source pulse, instead of a single one

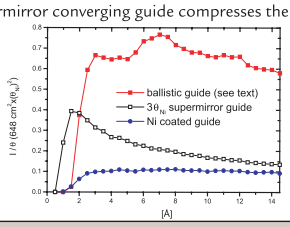


Time-distance diagram of IN500 spectrometer

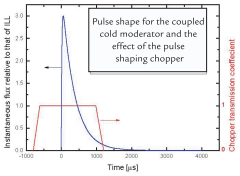


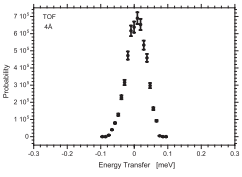
Calculated transmission at the sample position

- Low Loss Ballistic Neutron Guide
  - Absorption in guides leads to losses during reflections
  - To reduce losses: reduce the number of reflections:
    - a large cross section Ni guide transports neutrons over most of the distance
    - supermirror diverging guide ensures full illumination
    - supermirror converging guide compresses the beam



- Pulse tailoring by phased disc chopper
  - phased to cut the trailing edge of the source pulse in an adjustable manner
  - adjustable resolution to optimize intensity for each experiment





IN500 Specifications

Moderator	Coupled liquid H_2, FP13
Moderator-sample distance	63 m
Sample-detector distance	3 m
Wavelength definition choppers	at 7 m, 20 Hz at 31.5 m, 20 Hz
Resolution definition/ pulse-shaping choppers	at 31.35 m, 480 Hz (counter-rotating discs) at 62.5 m, 240 Hz (counter-rotating discs)
Pulse-filtering chopper	at 46.87 m, 320 Hz (single disc)
Ballistic guide	starts at 1.2 m, 61.3 m long
Detectors	10 m^2, pixel at 2 x 2 cm^2
Incoming wavelength range	2–20 Å
Resolution	adjustable, e.g.15-50 μeV at 7 Å incoming wavelength